Conseils Facteurs Humains
Human Factors Consulting

THALES

12om Methodology: Process v1.1

Prepared by:

Thales Canada, Defence and Security
1405 boul. du Parc-Technologique
Québec, QC G1P 4P5

C3 Human Factors Consulting Inc.
1405, boul. Du Parc-Technologique
Québec, QC, G1P 4P5

DRDC-RDDC-2014-C193
31 March 2014

Thales Document Control Number (DCN): 2014C.005-REP-03-AT5 Rev. 01
PWGSC: W7701-10307/001/QCL

Authors: Daniel Lafond
Jean-François Gagnon
Marie-Ève St-Louis
Sébastien Tremblay

Scientific Authority: Natalia Derbentseva
(416) 635-2000 x2302

ABSTRACT

The 12om project seeks to develop a methodology (i.e., process and tools) to improve the understanding of a complex situation by a multidisciplinary, government-wide team. The specific objective of this report is to describe and document the 12om *process* (v1.1). The 12om process aims to support teamwork and performance in the context of the current Canadian Forces Operational Planning Process (CFOPP), particularly during joint civil-military planning endeavours, such as whole-of-government approach initiatives. The present document is divided into three sections. First, it introduces the context of the project and outlines the method employed for the development of the 12om process. Second, informed by multiple sources, this report describes version 1.1 of the 12om process. This process includes three main dimensions: 1) A toolbox approach; 2) Training; and 3) Inclusion of an inter-agency planning specialist/facilitator. There is also a discussion of the sub-processes underlying the 12om methodology components. These components include the Whole-of-Government OPP handbook, the team building and handover procedure, the interactive common glossary, IMAGE v3 (i.e., individual and collaborative diagrams), the cross-impact method, the Op Design tool, and the mission analysis briefing template. Finally, in section three, the main features of Process v1.1, its limitations, and possible next steps are discussed.

EXECUTIVE SUMMARY

This work was conducted in support of the Applied Research Project (ARP) 12om entitled "Collaborative Understanding of Complex Situations". The overall purpose of this project is to develop a *methodology* (i.e., a combination of processes and support tools) to improve the understanding of a complex situation by a multidisciplinary team combining experts from different governmental departments. This document presents the results of work to develop the 12om process in three iterations, with the specific aim to support teamwork and performance in the context of the current Canadian Forces Operational Planning Process (CFOPP), in situations of interagency planning such as Whole-of-Government or Comprehensive Approach initiatives.

The specific objective of the current report is to describe version 1.1 of the 12om process – the third and final iteration planned within the scope of Project 12om. This iteration was performed following the completion of the Limited Objective Experiment (LOE) #2 and was informed by the pattern of results collected during the LOE (see ATT7 report "12om LOE #2: Final Results Summary and Recommendations").

Process v1.1 builds upon the toolbox metaphor from Process v0.2 (reported elsewhere, see ATT5 report "Development of the IMAGE process: Version 0.2). It complements the toolbox by providing details about the strength and weaknesses of each tool, informing commanders and interagency planning team members on their relative utility given the context of their mission. The process specifically highlights components' use and training time/effort as constraints, but also underlines their potential benefits to various collaborative understanding dimensions. Moreover, Process v1.1 appreciates individual components both in terms of flexibility and impact on taskwork to perform. Altogether, these assessments and recommendations about the toolbox are believed to provide great insights to the CF and other Canadian agencies and departments on the use of the 12om methodology.

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Acronym	Definition
ARP	Applied Research Project
CF	Canadian Forces
CFOPP	Canadian Forces Operational Planning Process
CIDA	Canadian International Development Agency
CIM	Cross-impact method
COA	Course of Action
CONOPS	Concept of Operations
DFAIT	Department of Foreign Affairs and International Trade
DP	Decisive point
LOE	Limited objective experiment
LOO	Line of operation
MA	Mission analysis
OPP	Operational Planning Process
PMESII	Political, Military, Economic, Social, Infrastructure and Information systems
ROC	Representative of Canada
SA	Situation awareness
SME	Subject Matter Expert
WoG	Whole of Government

1 Introduction

The document presents the 12om process, resulting from three major development iterations (version 0.1, 0.2, and 1.1). The 12om process aims to support interagency teamwork and performance in general and in the context of the current Canadian Forces Operational Planning Process (CFOPP) specifically. This work was conducted in support of the Applied Research Project (ARP) 12om entitled "Collaborative Understanding of Complex Situations". The overall purpose of this project is to develop a *methodology* (i.e., a combination of processes and support tools) to improve the understanding of a complex situation by a multidisciplinary team combining experts from different governmental departments.

1.1 Background

Collaborative mission analysis is an inherently difficult enterprise especially in a whole of government (WoG) planning context (e.g., Essens et al., 2013; Patrick & Brown, 2007). The 12om project seeks to identify and address these challenges through the following technical objectives:

1. Identify support requirements in Phase 1 of the case study, which will provide input into the design and development of support tools and processes to improve team collaboration within this type of context; and
2. To pilot the developed methodology in Phase 2 of the case study.

The project aims to improve the understanding of a complex situation by a multidisciplinary team and the specific collaboration context selected is a J5 integrated (or WoG) planning group. Furthermore, to keep the scope of the project manageable, the project focus is on the mission analysis (orientation phase of the operational planning process) and course of action (COA) development phases of the CFOPP. These two stages were chosen as a focus because most inter-agency collaboration occurs during these two stages of the CFOPP (Turnbull & Ulrich, 2013).

1.2 Operational Planning Process

The CFOPP is comprised of five main stages (see Figure 1):

- The *Initiation* stage results in the activation of the planning staff and the commander's guidelines about the kind of planning process to achieve;
- The *Orientation* stage results in the development of the commander's planning guidance. At this stage, the commander orients his/her staff towards the determination of the nature of the problem and the confirmation of the results to be achieved;
- The *COA Development* stage results in the production of the CONOPS (CONcept of OPerationS) that identifies the commander's line of action in order to accomplish his/her mission. It presents the COA that will be implemented;

- The *Plan Development* stage results in a set of orders based on the commander's decision to provide subordinate and supporting units with all of the necessary information to initiate the planning or the execution of operations; and
- The *Plan Review* stage results in a regular review of the plan to evaluate its viability. The review period of the plan depends on the evolution of the situation, the type of operation and the environment.

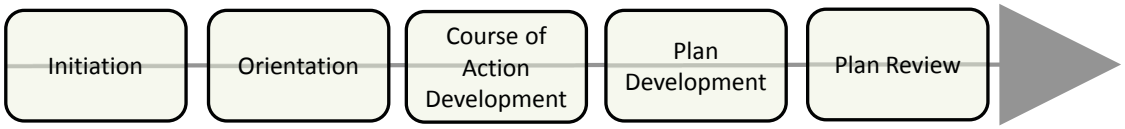

Figure 1: Five phases of the Canadian Forces Operational Planning Process

Figure 1 also illustrates an ideal state in which the whole OPP is performed flawlessly in terms of the quality and timeliness all five components of the process (i.e., a straight arrow). However, the inherent complexity of planning within a WoG context makes accomplishing this ideal state extremely unlikely. Rather, sub-optimal team dynamics, poor shared awareness and high levels of workload (amongst other team-centred factors) are likely to lead to sub-optimal planning performance (e.g., Turnbull & Ulrich, 2013, see also Figure 2 for an example).

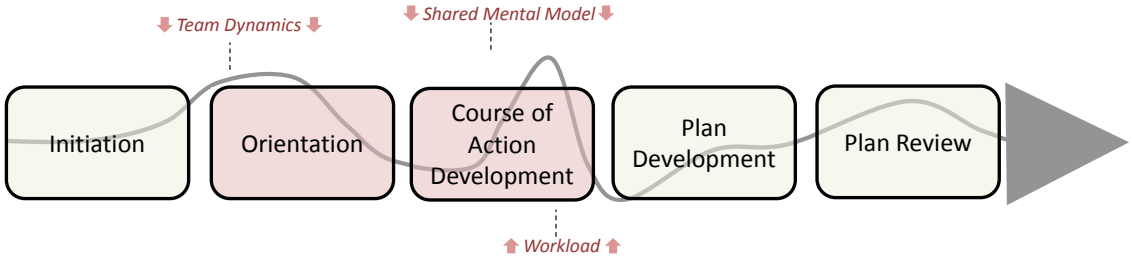

Figure 2: Team-centred factors leading to sub-optimal Orientation and COA Development performance

The overall purpose of the 12om project, therefore, is to develop and evaluate a *methodology* – by which we mean a coordinated suite of process improvements and support tools – to improve collaboration in multidisciplinary teams. The context in which the methodology is tested is the CFOPP within a J5 WoG planning group. For example, Figure 3 illustrates a hypothetical scenario within which a combination of process improvements and support tools have been used to address the planning deficiencies identified in Figure 2. In doing so, the overall CFOPP process performance is improved to an acceptable level.

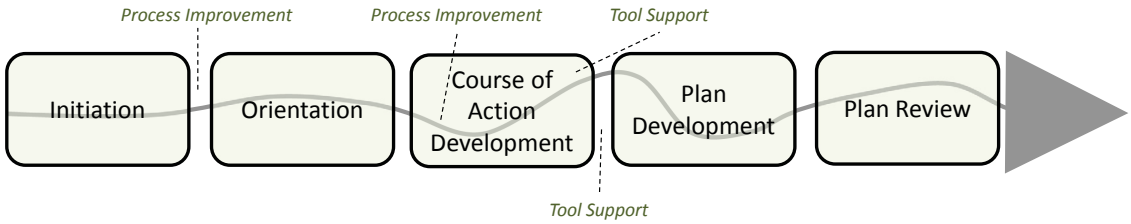

Figure 3: Illustration of how the 12om project seeks to improve the CFOPP through the development and application of a novel *Methodology*

1.3 12om Project Objectives

One frequent criticism of the standard CFOPP process is that it is not very well suited to deal with complex situations (Lauder, 2009). Complexity can lead to poor quality decisions because planners might possess a different understanding of the situation, misunderstand their commander's intent, or are not clear about the roles, relationships, tasks, and success criteria. Design can be seen as a critical thinking method that is aligned with the principles and objectives of the comprehensive approach to military decision making. The so-called "art of design" (Banach, 2009; Banach & Ryan, 2009) aims at helping planners to better understand the operational environment (i.e., *sensemaking*), analyze the problem space, and consider potential solutions so they can exploit opportunities and identify vulnerabilities. The methodology developed as part of the 12om project should, therefore, maximize the fit across the processes involved in collaborative sense-making, the techniques for knowledge representation, and the tools required to support the expression and sharing of this knowledge across the planning team.

In summary, the 12om project seeks to develop a *methodology* (i.e., process and tools) to improve the understanding of a complex situation by a multidisciplinary, government-wide team. The overall objectives of project are to:

1. Develop a process based on an understanding of the collaborative process through which expert teams understand complex situations;
2. Investigate and develop tools to support this process; and
3. Empirically evaluate the methodology (i.e., a coordinate suite of process improvements and support tools) developed.

The specific objective of the work reported in this report was to inform the development of the three major iterations of the 12om *methodology* (i.e., a combination of tools and processes) based on support requirements captured from the following sources:

1. Empirical evidence from the LOE #1 and LOE #2;
2. Subject Matter Expert (SME) feedback obtained during and after LOE #1;
3. Tool and process recommendations developed as part of the previous report entitled "State-of-the-Art on Operational Design Processes and Representation Techniques" (2014C.003-REP-01-AT3);

4. Subjective assessments of the tool/process feasibility and impact on the OPP by the project team; and
5. Subjective assessments of the tool/process feasibility and impact on the OPP by domain experts. The data was collected through a series of workshops.

The methodology used by the project team to capture, consolidate, prioritise and synthesize the tool and process 'solutions' identified during the earlier phases of the project is described in detail in the following section.

1.4 Process Development Methodology

The following section describes the general methodology that was used to develop each of the three 12om process iterations (v0.1, v0.2 and v1.1). The methodology employed for Process v.01 is presented in Figure 4 and explained in detail below.

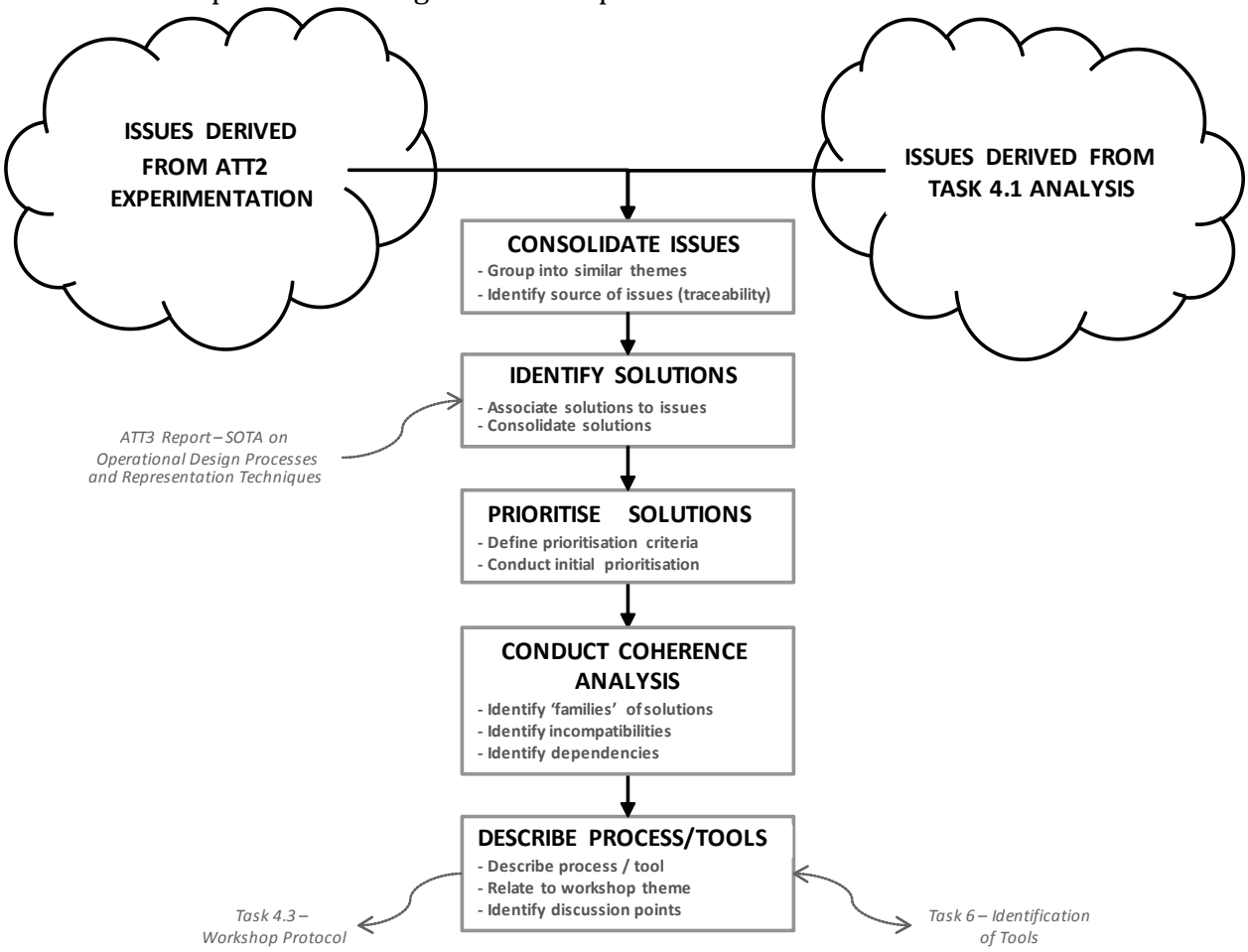

Figure 4: Methodology used to develop Process v0.1

- *Consolidate Issues*: The first step was to consolidate the list of issues identified by both the empirical results from the LOE #1 (and Task 4.1 Analysis) and comments

from the SMEs themselves recorded during and after the experimental sessions. These issues were then grouped into similar themes and the source(s) of the issues (e.g., experimental metric, SME comment, etc.) recorded and tabulated.

- *Identify Solutions*: The second step was to identify and consolidate solutions from both the ATT3 report "State-of-the-Art on Operational Design Processes and Representation Techniques" and feedback received from SMEs during de-briefing sessions conducted immediately after LOE #1. Once again, this information was recorded in table format to expedite the prioritisation process of step 3.
- *Prioritise Solutions*: The solutions identified in step 2 were then prioritised against several criteria, including Mandatory, Primary, Secondary and Tertiary criteria in terms of importance for the current project. Each solution was rated against the criteria by the project team in order to identify a short-list of solutions for further analysis.
- *Conduct Solution Coherence Analysis:* We analysed the interrelationships between the short-listed solutions in terms of identifying both general themes of support, as well as dependencies and incompatibilities between them. The intention was to get a sense of the coherence of solutions to work out recommendations arriving at a harmonious set of tools and processes.
- *Describe Process / Tools*: The last step was to describe the short-listed tools and processes in more detail in order to support both the implementation of these solutions for LOE #2, and the development of discussion points for the forthcoming SME workshop. In addition, this work will support (and be informed by) parallel activities pertaining to Task 6 "Identification of Tools".

- *Workshop protocol*: Finally, a series of workshops (task 4.3) was conducted to get feedback from SMEs. The comments were used to refine the initial version of the 12om process (v0.1) into its second iteration (v0.2).

The methodology employed for the development of Process v0.2 involved creating a short-list of potential components and presenting it in a series of workshops to SMEs from the CF, CIDA, DFAIT and Calian. Two workshop cycles were conducted. Cycle one involved four distinct events (Workshop 1a, 1b, 1c, and 1d) whereas cycle two involved a single event (Workshop 2) after revising candidate components based on Cycle 1 results. Workshop 2 made use of a serious game scenario (Peacemaker), to create a relevant context for the hands on methodology component exercises without requiring excessive reading time from the participants. Each workshop event was conducted in a small group with two to eight SMEs. Workshops involved domain experts from DFAIT (Workshop 1a and 2), CF (Workshop 1b and 2), Calian (Workshop 1c), and CIDA (Workshop 1d and 2). Each event consisted of several activities including presentation of the results of the first experiment (and/or previous workshops), presentations and demonstrations of the methodology components by the research team, focus group discussions identifying target areas for process and tool support, hands-on trials of the methodology components, participants'

evaluation and suggestions for improvement, and functional gap analysis. Results from these workshops provided the necessary insights to achieve the development Process v0.2. A dry-run serving to pre-test the 12om Process and Tools with Calian personnel allowed fine-tuning Process v0.2 in preparation for LOE#2.

The development of Process v1.1 was based on the results from LOE #2. LOE #2 involved, a simulated WoG effort carried out to respond to a polio outbreak in the horn of Africa (i.e., Somaliland, Ethiopia, Djibouti). A WoG team of five members was created for that purpose (three from the CF [J5, J52; J5Ops] and two civilians [J5Dev and J5Gov]). Four SME observers also participated in the LOE #2, two of them playing the role of ROC and Commander. The detailed LOE procedure, measurements and results are described in report 2014C.007-REP-04-AT7 (see also Appendix A for key observations with regards to 12om Process v1.1). Following LOE #2, the development of Process v1.1 involved extracting key results (e.g., collaboration pattern, strengths, weaknesses, tool synergies) to guide the design of the final process improvements. Using the MYRIAD multi-criteria analysis tool, we designed a preference model that combines different key results into a coherent assessment of the overall 12om methodology and its components. Furthermore, MYRIAD allowed performing a sensitivity analysis in order to derive the most promising areas for improvement.

1.5 Document Overview

This document describes the work performed to develop the 12om process. The document is organized as follows:

- *Section One: Introduction*. This section provides the background, purpose and objectives of the study, the process development methodology, together with an overview of the document;
- *Section Two: Process v1.1.* This section presents Process v1.1 of the 12om methodology. This process includes three main dimensions: 1) A toolbox approach; 2) Training; and 3) Inclusion of an inter-agency planning specialist/facilitator.
- *Section Three*: *Conclusion.* This section summarizes the main features of the 12om process, reviews the main limitation of the approach as it is now, and discusses the next steps of this research endeavour.

2 12om Process v1.1

The overall purpose of this project is to develop a *methodology* (i.e., a combination of process and support tools) to improve the understanding of a complex situation by a multidisciplinary team combining experts from different governmental departments. More precisely, the methodology aims to support teamwork and performance in the context of the current CFOPP. This section describes the ***process*** of the 12om methodology.

The 12om process is based on the toolbox metaphor. According to this metaphor, a series of "simple" tools, when used in the right context, outweighs the benefits of a single "complex" tool aiming to be generically applied to various contexts. In that regard, the components integrated within the 12om methodology are not intrinsically good or bad, but must be used in an adaptive manner. The process explicitly states specific conditions under which each component should provide effective support. When applying these conditions in the context of OPP, a natural sequence of use emerges. Indeed, the outputs of earlier components can be used as inputs for latter components. Although each component could be used independently from the others, the natural sequence may be beneficial by itself in terms of support to J5 integrated teams.

The pattern of results, observations and SME comments obtained from the experiments and workshops suggest that a complete training in the whole 12om method prior to starting such an exercise would allow a more effective use of the methodology components. Consequently, the process involves training for all components to efficiently show how to fully exploit each component.

Moreover, because of the potential complexity in using some of the components, the 12om process ideally involves the inclusion of an interagency planning specialist/facilitator (with modeling expertise) within the team. In particular, while the core features of the IMAGE v3 tool are deemed valuable for most users, the more complex ones, using the specialized features require a particularly well-designed training package or to be supported by a specialized facilitator. One additional potential advantage of having an interagency planning specialist within the team is to ensure that one team member is not associated to a specific LOO. Having such a team member with no a priori agenda may also help to ensure a more balanced consideration of factors. Finally, one of the key roles of the specialist/facilitator could be to actively gauge and support collaborative understanding – particularly using communication reflection techniques such as mirroring and paraphrasing.

In summary, the 12om process involves three main dimensions:

1. A toolbox approach;
2. Training; and
3. Inclusion of an inter-agency planning specialist/facilitator.

Herein, we discuss how these dimensions can be integrated into a comprehensive, yet modular approach to understanding complex military situations: i.e., the 12om process.

2.1 A Toolbox Approach

The version 1.1 of the 12om process is based on a "toolbox" approach (Gigerenzer & Gaissmaier, 2011; Gigerenzer & Selten, 2001; Gigerenzer, Todd & al., 1999). Research in various domains suggests that the strength of a toolbox approach lies on the fact that a given methodology component is not intrinsically good or bad in enhancing analyst' comprehension, but that its utility has to be determined in relation to the characteristics and constraints of the task (Dieckmann & Rieskamp, 2007; Rieskamp & Otto, 2006). Such constraints, for instance, are temporal pressure (Karelaia & Hogarth, 2008) and uncertainty (e.g. Marewski & Schooler, 2011). One single component doesn't have to be applied to all contexts as they can be handpicked at will when relevant. For instance, in time pressured tasks where quick action is required, one might not have the time to develop an integrated representation of the situation with a knowledge representation tool, however, they may benefit from such a representation if the situation does not require quick actions.

Here, we first describe the components integrated within the 12om toolbox and describe their specific process. After, we review the conditions under which each of the components seems to be the most useful. Finally, we recommend a natural sequence of when they should be used, relatively to their specific characteristics and environmental constraints.

2.1.1 Tools

Seven tools (or components) are integrated within the 12om process: (1) WoG OPP handbook, (2) Team building and handover procedure, (3) Interactive common glossary, (4) IMAGE v3 (i.e., individual and collaborative diagrams), (5) Cross-impact method, (6) Op Design tool and (7) Mission analysis briefing template. Selection and integration of these components is based on the assessment by DRDC experts of the critical results from the previous workshops and experiments. Although these components are integrated within the overall 12om process, they are all characterized by an inner micro-process. This section overviews the 12om components by providing a short description and briefly explaining their respective process.

2.1.1.1 WoG OPP Handbook

The WoG OPP handbook is a small document destined to the members of joint civil-military planning endeavors, such as WoG approach initiatives. It comprises of a summary of the main phases of the OPP and associated sub-tasks. The purpose of the handbook is to inform joint civil-military teams about what is expected from them. The integration of this component is justified by the observed discrepancies on the understanding of the OPP across team members, especially between civil and military members. The lack of understanding of the OPP by some of the civilian members may be responsible for their low implication during the OPP.

The process associated with this specific component is to distribute the handbook to all members of the planning team prior to deployment. The handbook is expected to serve as reference material; so each team member can consult the handbook when needed.

2.1.1.2 Team Building and Handover Procedure

Team building and handover procedure consists of a set of activities aiming to foster knowledge about the team's goal and objectives, team members' expertise and specific knowledge, and about the process that will be followed by the team. Information captured during this set of activities is recorded on a shared drive to facilitate handover. The integration of this methodology component within 12om is justified in part by the lack of cohesion between members of the team (especially across agencies) which has been outlined by the SMEs during the series of workshops.

The process involved with this component is set in two phases. Both phases engage the J5 (or other previously identified exercise lead) to lead a round table discussion aiming to collect and share information about the members of the team. The first phase occurs before the initial mission analysis brief. Its objective is to capture general knowledge of the team's member. Such knowledge consists of information about previous experience of team members in similar contexts, expected departure date, and tool-related skills, for instance. The second phase, occurring after the initial mission analysis brief, aims to develop a common picture of the team's goal and of the process that will be carried out to achieve this goal. A secretary captures as many of the information possible in a provided excel file template. This file is not shown to participants during the exercise as it is potentially too distracting. The file is placed on a shared drive and each participant is responsible for checking, reviewing and updating his/her own information during the mission.

When turnover of personnel is predictable, J5 outlines the desirable procedures for preparation and handling of personnel turnover as part of the process. This process involves the following element. Team members are asked to notify the J5 when their departure date is known. Team members should establish, when possible, communication between incoming and departing team members as soon as possible. In order to develop incoming member's understanding of the mission, the departing member should include the incoming member in all his/her relevant correspondence. Finally, departing member should stay in touch with the replacement even after his/her own departure from the team.

This process is greatly facilitated by higher levels of command is there is a consideration for early identification of replacements, planning for overlapping periods between incoming and departing team members, and active support for facilitating communications between them.

2.1.1.3 Interactive Common Glossary

The interactive common glossary is a tool that centralizes and defines situation-related terms and acronyms. Its purpose is to foster the use of a common language during the OPP. The integration of this methodology component within 12om is justified by the observed

discrepancies observed between individuals and/or agencies which often lead to miscomprehension and lack of collaboration.

The process involved with this component is unique as it would ideally always be on-going, even before mission analysis even starts. The common glossary should be distributed across relevant organizations so that they can consult and modify it at will. This would raise acceptance and relevance of the component across organizations. During a planning mission, since the component is mostly reference material, it should be used when needed, individually.

2.1.1.4 IMAGE v3

IMAGE v3 is a set of tools and techniques that aims to facilitate the integration of different perspectives on a situation into a single visual representation. Depending on the level of achieved formalism, this representation can be a sole description of the situation or a computational model of a complex system. The integration of this component within 12om is justified by the difficulties observed in comprehensively representing complex situations in the context of OPP. Moreover, this component seeks to foster the integration of multiple perspectives, which is also frequently lacking in this context.

Although the final decision should always be the prerogative of the leader of the WoG team, we suggest, based on feedback from participants and our observations, that planning teams engaged in the creation of conceptual diagrams should begin with the creation of a *collaborative* diagram rather than individual diagrams.

However, if individual diagrams are created, the process should include specific tasks. Since the intention of individual conceptual diagrams is to ultimately integrate them into a common representation, an initial coordination about the main parameters (e.g., scale, level of details) and major concepts/issues would give a good starting point for the individual work and significantly facilitate future integration. Because one of the main issues associated with this component is the time requirement, the lead of the mission (e.g., J5) should be aware of the costs of using IMAGE v3 (in terms of time needed to carry out the analysis) in order to make an informed decision about its adoption or not in the context of the mission.

2.1.1.5 Cross-Impact Method

The cross-impact method is a structured way to analyse a situation and increase awareness of critical interactions. It aims to improve shared awareness of the multiple factors involved, to make salient key divergences in understanding among a team and to minimize tunnel vision by promoting a comprehensive consideration of factors' direct and indirect effects. Moreover, in the suggested implementation, the cross-impact method also promotes option awareness, that is what can be done to improve a particular variable within the system. Despite lower ratings from SMEs concerning the feasibility of implementing such a component within the OPP, the integration of this component within 12om is justified mainly by the need for a method that can bridge the gap between

situation representation and initial course of action development. Accordingly, the method has undergone several modifications in response to SMEs comments and suggestions. For instance, the size of the matrix is now limited to 9X9 in order to reduce its complexity and the time required to perform the analysis. A more easily understandable graphical output is now also generated to facilitate the interpretation of the method and its use as a communication tool.

The CIM follows a three-step approach (two mandatory, one optional). The first step aims to identify and select the elements to be included in the analysis. The second step is to map these elements against each other and determine their mutual influences. Finally, the third step is to define possible interventions and assess their impact.

Step 1 – Variable identification. This step is broken down further more into two sub-steps: select variables and specify subgoals. Subgoals are critical for the analysis because they allow assessing how different effects relate to the mission objective. Variables that are not subgoals are influencing factors. Influencing factors directly or indirectly impact subgoals. Note that subgoals can be influencing factors as well, but the label "subgoal" takes priority.

> *Sub-Step 1.1 – Variable selection*. In the context of a planning team, the process for selecting variables is democratic, each team member voting for the desired variables.
>
> *Sub-Step 1.2 – Specify subgoals directionality*. You may seek to maximize or minimize a given subgoal. For instance, "crime" is not a subgoal per se, but "minimizing crime" might be one. The second step of variable identification aims precisely at specifying the direction of the subgoals (which is critical for the analysis). Here, there is no specified process on how to establish goal directionality as it depends heavily on the context (e.g., the goals and subgoals may be specified by higher levels of command).

Step 2 – Influence mapping. This step is also broken down into two sub-steps. The first step is to actually perform the mapping of the influences between the selected variables. The second step is to assess the output generated by the mapping.

> *Sub-Step 2.1 – Cross impact mapping*. One row at a time, team members must map the effects of the variable on the left on the variables in each column, if applicable. This process should be supported by a facilitator. It is critical that the mapping reflects direct influences only rather than covariation of variables.
>
> Sub-Step 2.2. – Review output. The output will order the most influencing variables (positive and negative) with regard to priory specified subgoals. This information may be critical for sequencing decisive points when using the Op Design tool. A decisive point is a specific key event, critical factor, or function that, when acted upon, allows commanders to gain a marked advantage over an adversary or contribute materially to achieving success. Decisive Points may exist in time, space

or in the information environment. Since decisive points need to be ordered into lines of operations (i.e., because limited manpower/resources require actions to be performed sequentially), the selection of which action to do first can be guided by the expected payoff of the CIM (doing high payoff actions first will "generate more interest" over time). There are other considerations for decisive point analysis, such as sequential dependencies, or potential conflicts/synergies when synchronising some decisive points.

Step 3 – Intervention matrix. This optional step is also divided in two sub-steps: intervention mapping and output review. The purpose of the intervention matrix is to allow for a comparison of up to nine potential interventions. Cost-benefit assessment of the direct impacts of each intervention on subgoals (1st order effects), plus the overall impacts on subgoals (last column of the cross impact matrix) of the variables influenced by the intervention (i.e., 2nd and 3rd order effects). Note that reducing an unfavorable variable whose global impact is -5 counts as a favorable effect of 5.

Sub-Step 3.1 – Intervention mapping. One row at a time, team members must map the effects of the possible interventions on the variables, if applicable. This process should be supported by a facilitator. It is critical that the mapping reflects direct influences only rather than covariation of variables.

Sub-Step 3.2. – Review output. Similarly to step-2 output, step-3 output graph provides guidance with regards to decisive point sequencing, assuming that an intervention can be readily associated to a decisive point. In addition to the order of decisive points, this assessment may motivate the addition/removal of a decisive point (in the case of interventions with counter-intuitively favorable/unfavorable systemic impacts).

2.1.1.6 Op Design Tool

The Op Design tool aims to support planners in sequencing decisive points into lines of operations and to identify operational phases with their associated objectives and tasks. It provides the grounds to initiate the thinking required to identify possible branch plans and/or sequel plans where transition conditions are desired. The integration of this component within 12om is justified by the need for initial OP Design during the orientation phase of the OPP and the limited capabilities of the other components to satisfy this need.

The process of decisive point analysis using the Op Design tool is composed of six steps:

(a) Step 1 – Identify decisive points,
(b) Step 2 – Sequence decisive points,
(c) Step 3 – Identify phases,
(d) Step 4 – Identify objectives,
(e) Step 5 – Identify tasks, and
(f) Step 6 – Identify branch, think about sequel.

2.1.1.7 Integrated Mission Analysis Briefing Template

The integrated MA briefing template intends to help clarify the nature of the output required by each team member and to reduce formatting work for the mission analysis brief. The integration of this component in the 12om toolbox is justified by the fact that a pure military template for MA briefing may not capture aspects relevant to other agencies like CIDA and DFAIT.

The MA briefing template does not involve a specific process per se. The only "process" would be that the template should be reviewed and filled out by the team collaboratively rather than by separating the job across individuals. This would allow for a better integration of the different lines of operations involved in the planning endeavour.

2.1.2 The Right Tool for the Right Task: Linking Tools to the Process

As mentioned earlier, none of the components integrated within the 12om methodology is mandatory when performing OPP. Each component can be hand-picked in an adaptive manner, when relevant. *Utility* of each component will vary given the characteristics of the tasks to be carried out. Herein, we highlight the favourable conditions of the use of each component, in particular during initiation and orientation phases. This is done by making explicit the conditions under which the characteristics of the component fit with the characteristics of the task. This proposition is based specifically on the evaluations of the components by the SMEs and observations made during experimentations.

In addition to the description of the tools, the present section provides means to link the 12om components with the tasks to be carried out and consequently specify the process on step further. The goal here is to escape from the tool-specific process by considering the process of the whole 12om toolbox. The conditions stated below are the considerations that allow a planner to choose which components he should use for his work. Moreover, the conditions specified below are generic enough to be applied to a wide variety of contexts, including but not reserved to CFOPP.

2.1.2.1 WoG OPP Handbook

The WoG OPP handbook would ideally be handed out prior to actual work. Conditions favourable to the efficient use of WoG OPP handbook are:

- **Knowledge of the staff involved in the mission –** If the staff is unknown before the mission, it won't be possible to distribute the handbook;
- **Guideline –** The handbook describes the original OPP. Any deviation from it in the operational context will not be captured by the handbook. Therefore, the handbook should be considered as a flexible guideline rather than a prescriptive method; and
- **Low time pressure –** If the mission requires quick deployment and actions, the time available to read the handbook may be very limited and therefore render its use irrelevant.

2.1.2.2 Team Building and Handover Procedure

The team building and handover procedure should be completed at the very beginning of the mission (or even before according to some SMEs). Conditions in which this procedure would be the most useful involves:

- **Non-conflicting agendas -** The application of this procedure will be limited if team members have conflicting agendas, and therefore cannot attend the meeting. Ideally, this procedure would involve all J5 integrated team members;
- **Interoperable systems** - This procedure would be more beneficial if all staff members share the same working environment. This would be necessary to easily access and update the information collected during the procedure;
- **Low time pressure –** The use this method may be time consuming. Therefore, if the mission requires quick actions, it may not be possible to use this component effectively; and
- **Uncertainty –** This procedure would reduce uncertainty associated with the beginning of a mission, especially uncertainty pertaining to the mission's objective and the OPP process.

2.1.2.3 Interactive Common Glossary

The interactive common glossary can be useful throughout the OPP. Conditions in which the common glossary would be the most useful involves:

- **Multi-agency –** Terms are more heterogeneous across agencies than within agencies. Therefore, a multi-agency team may benefit more of a glossary than a single-agency team;
- **Interoperable systems -** The interactive common glossary would be effective only if accessible to all team members; and
- **On-going consultation and modifications** - The general glossary requires on-going consultation and modifications between departments to build visibility and acceptance.

2.1.2.4 IMAGE v3

IMAGE v3 is used for the creation of conceptual diagrams. Conceptual diagrams are useful for integrating different perspectives into a single representation, and describing the situation either individually or collectively. The conditions in which IMAGE v3 would be the most useful involves:

- **Multiple agencies –** Collaborative knowledge representation would facilitate the identification of differences between LOOs. Moreover, the use of representation fosters collaboration between team members. Therefore, the use of this component is adapted to a multi-agency mission;
- **Common terminology –** Divergence in vocabulary terms when using collaborative representation tool may be an issue. Henceforth, the use of such tool would benefit from the use of a common glossary tool in parallel, such as the one suggested in the actual 12om toolbox;

- **Complex situations –** The use of such representation helps in making sense of complex situations. IMAGE v3 is useful for identifying additional factors and influences, and stimulating reflection on key assumptions;
- **Low time pressure -** The use of IMAGE v3 may be time consuming. Therefore, if the mission requires quick actions, it may not be possible to use this component effectively. Some SMEs even suggested that this component could be used before mission analysis;
- **Work in progress –** IMAGE v3 is a great "thinking" tool, but not so great for briefing purposes, because the resulting product – the diagram – can easily get too complex impeding its readability. Therefore, these tools should be used mainly during the review of the situation and factors analysis; and
- **Specialized knowledge –** The complexity of the tools makes it difficult for novices to use. Therefore, the presence of a team member specialized in the use of such tools would be a favourable condition.

2.1.2.5 Cross-Impact Method

Cross-impact method aims to improve shared awareness of the multiple factors involved, to make salient key divergences in understanding among a team and to minimize tunnel vision by promoting a comprehensive consideration of factors' direct and indirect effects. Based on the information collected during workshops, the context in which cross-impact method would be the most useful involves:

- **Complex situations -** The use of the method helps in making sense of complex situations because it forces its user to systematically evaluate the relationships between the variables of a situation;
- **Low time pressure –** The use this method may be time consuming. Therefore, if the mission requires quick actions, it may not be possible to use this component effectively. A first draft of the CIM could be completed by the specialist to considerably reduce time/effort required from the entire team, which could then refine that draft collaboratively;
- **Leadership –** Due to the level of training and the time required for completing the CIM collaboratively, there is a risk that the tool would be skipped in the absence of leadership to use it. This leadership could come from a specialist/facilitator already familiar with this component;
- **Interest in general dynamics –** This method will help understand the general dynamics involved in a system. It won't help in finding idiosyncrasies or micro patterns of evolution, e.g., it will not help identifying who the key leader is in a local insurgency group, but it may help identifying the overall impact of the group on the security in the region. This is partly due to the difficulty to include some types of variables such as terrain, and on the combinatorial complexity associated with the addition of new factors (the analysis focuses only on the most critical factors);
- **Course of actions –** The action-oriented section of the method may be premature for mission analysis, and may perhaps be more suited for initial COA development. This step is therefore optional for mission analysis, but can be useful for Op Design since is supports option exploration and DP sequencing; and

- **Briefing –** The output of the method could be a nice addition for briefing.

2.1.2.6 OP Design Tool

The Op Design tool aims to support the planners in their brainstorming to sequence decisive points into lines of operations and to identify operational phases with their associated objectives and tasks. Based on the information collected during workshops, the context in which DP Analysis would be the most useful involves:

- **Planning –** DP analysis will be mostly relevant in the OP Design phase of mission analysis;
- **Multiple objectives –** This analysis is very relevant to take multiple objectives into account;
- **Multiple agencies -** This analysis is very relevant for synchronising/coordinating multiple LOOs in the achievement of multiple goals;
- **Time horizon –** The multiple objectives and agencies should have similar timelines. The effective use of this component will be more difficult if, for instance, one organisation has a 1-year horizon for its objective and another has a 5-year horizon;
- **Briefing –** SMEs agreed that the analysis produces a useful output for briefing;
- **Interoperable systems/procedure –** The SMEs stated that the method would work best in conditions where the interoperability with other systems would be high. For instance, SMEs from CIDA stated that they approach situations differently (change oriented rather than action oriented) and that it may not fit with the approach used in decisive point analysis;
- **Specialized knowledge –** The complexity of the tool makes it difficult for anyone to use it at hand. Therefore, the presence of a team member specialized in the use of the tool would be a favourable condition; and
- **Course of actions –** The component may be premature early in mission analysis, and may perhaps be more suited for initial OP Design and COA development.

2.1.2.7 Integrated MA Briefing Template

The integrated MA briefing template intends to help clarify the nature of the output required by each team member and to reduce formatting work for the mission analysis brief. Based on the information collected during workshops, the context in which integrated MA briefing template would be the most useful involves:

- **Multiple agencies –** The template is designed to facilitate the integration of multiple perspectives on the situation;
- **High time pressure –** The template facilitates putting together the evidence and information collected by the team into a comprehensive frame. It may help structure teamwork and consequently, increase work efficiency. Therefore, the template should help the team to produce an output faster; and
- **Uncertainty –** The integrated template clearly states the required pieces of information required for the MA template. Consequently, it may help decrease uncertainty associated with the nature of the deliverables requested from the team; and
- **Collaborative effort -** The process for preparing briefing should be collaborative.

2.1.3 12om in the Context of OPP

The conditions listed above are useful for guiding the selection and use of the appropriate component in the context of a specific planning endeavour. In addition, a functional gap analysis (See Appendix A) revealed that some components are general whereas others are specific. Together, these analyses show that the components should not be used without considering their strengths and weaknesses.

Other considerations should be taken into account when sequencing the use of the components: the leverage effect of the outputs, specifically. For instance, the output of collaborative knowledge representation can feed the cross-impact method, and the output of the cross-impact method can be integrated in the MA briefing template. Here, we list how some of the output of the 12om components can be re-used into another component and provide a leverage effect.

1. The *WoG OPP handbook* does not generate any output per se, however, the knowledge gained from it is useful throughout the whole OPP. Consequently, one could say that the WoG OPP handbook indirectly facilitates the process of all components.
2. The objectives specified during the second phase of the *team building procedure* could serve as a basis for the sub-goals identified in the cross impact method and/or the Op Design tool. Although this is not a direct use of the output, it could nonetheless facilitate the process.
3. The terms defined in the *common glossary* could be used in all other components. It could be used as reference material to inform a user about the meaning of a term/acronym in a document. It could also be used as a form of constraint when using other components to ensure the use of common terms by the team, notably in IMAGE v3, the cross impact method, the Op Design tool, and the mission analysis briefing template.
4. *IMAGE v3* outputs come in many formats which can all be used for different purposes. The graphical outputs generated could be integrated within the mission analysis briefing template, depending on the commander's will. It may serve as a support for the presenter during the brief. The table format outputs generated by IMAGE v3 can be imported directly into the cross impact method and the Op Design tool. The table format outputs can greatly facilitate the variable selection process of the cross-impact method and the five first steps of the decisive point analysis using the Op Design tool.
5. The *cross impact method* also generates both a graphical and a table format output. The graphical outputs of the cross impact method may be integrated within the mission analysis briefing template to support the presenter during the mission analysis brief. On the other hand, the table format output could be imported back into IMAGE v3 and provide basis for the development of a new knowledge representation.
6. The *Op Design tool* generates a very useful graphical representation that shows inter-relations across the lines of operations with regards to the mission's

objectives. This graphical representation could be copy pasted into the mission analysis briefing template and be used for supporting the presenter during the brief.
7. The *integrated mission analysis briefing template* is expected to provide a structure to the mission analysis brief. Consequently, this structure could be used during the actual mission analysis brief.

By considering (a) the mapping between components and the OPP tasks, combined with (b) the functional gap analysis conducted during the LOE#2 (see Appendix A), and (c) the leverage that can be obtained by building upon the outputs of each components, the sequencing of the components during OPP results into a "natural" sequence of introduction and usage of the 12om methodology components. This natural sequence is shown in Figure 5 and Figure 6.

2.2 Training

The second dimension of the 12om process relates to training. Training is critical in the context of the 12om methodology and has to be emphasised as an important dimension of the 12om process. A training package is available elsewhere (see ATT7 deliverable "Training Modification Recommendations") and serves as a guide through the training process. The training is divided into three steps:

1. Contextualization,
2. Introductory training, and
3. Specific training and exercises.

2.2.1 Contextualization

This step mainly describes the objectives (i.e., supporting WoG teams in the comprehension of complex situations), the scope (i.e., initiation and orientation phases of the CFOPP), and the target areas of the 12om methodology (i.e., shared understanding, collaboration, and integration of different perspectives). It is a high level description of the context of application of the methodology.

2.2.2 Introductory Training

This step describes the toolbox approach of the 12om methodology. It stresses that a particular component is not good or bad per se, but that its effectiveness is determined by the characteristics of the tasks to be carried out. Afterward, the training presents all the components of the 12om toolbox in terms of purposes and other key characteristics. For instance, it enumerates how the outputs of each component can be useful to the other ones. Finally, the natural sequence emerging from the mapping between tasks characteristics and favourable conditions of use is presented.

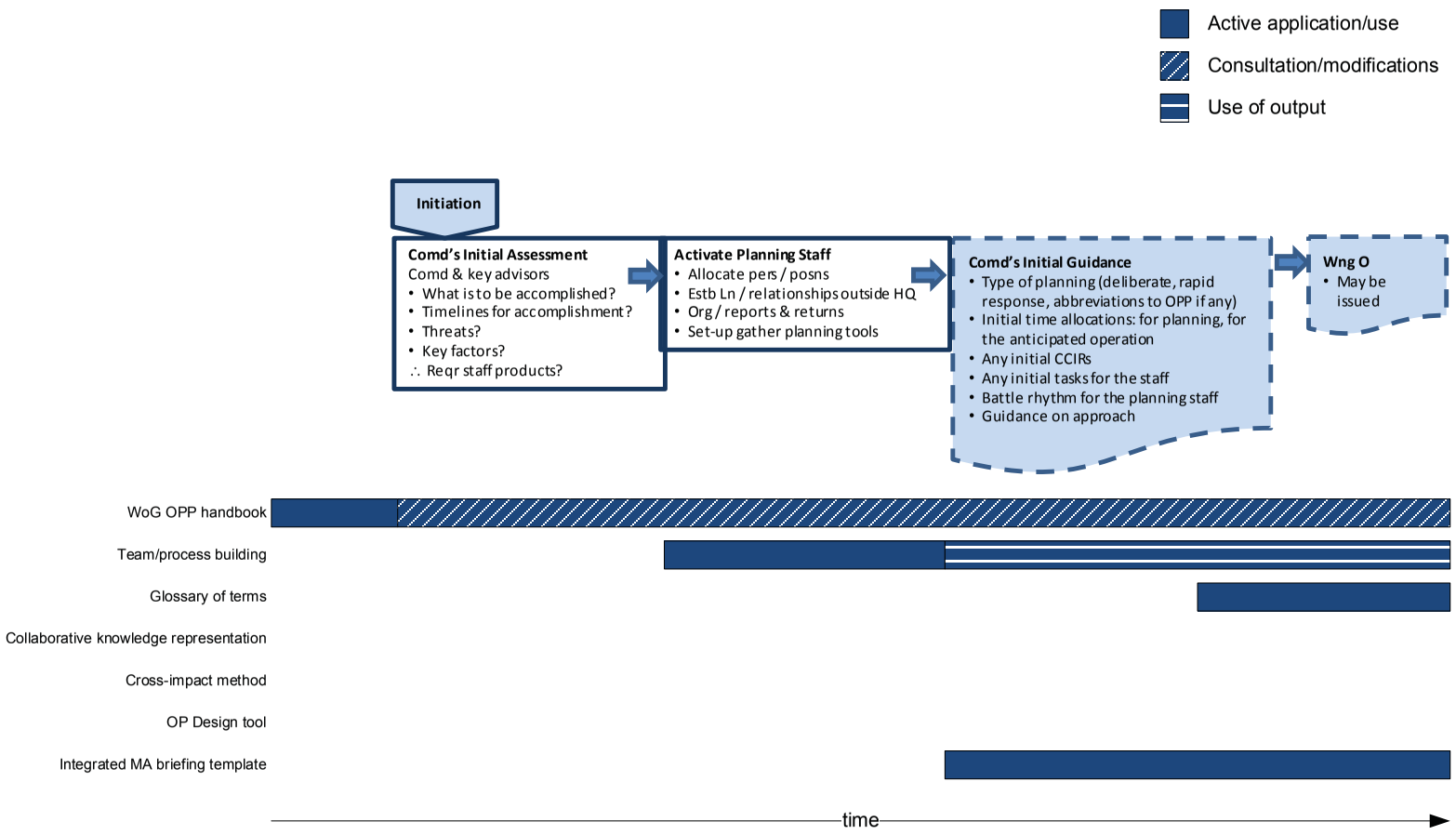

Figure 5: Suggested use of the 12om methodology components during the initiation phase of the OPP.

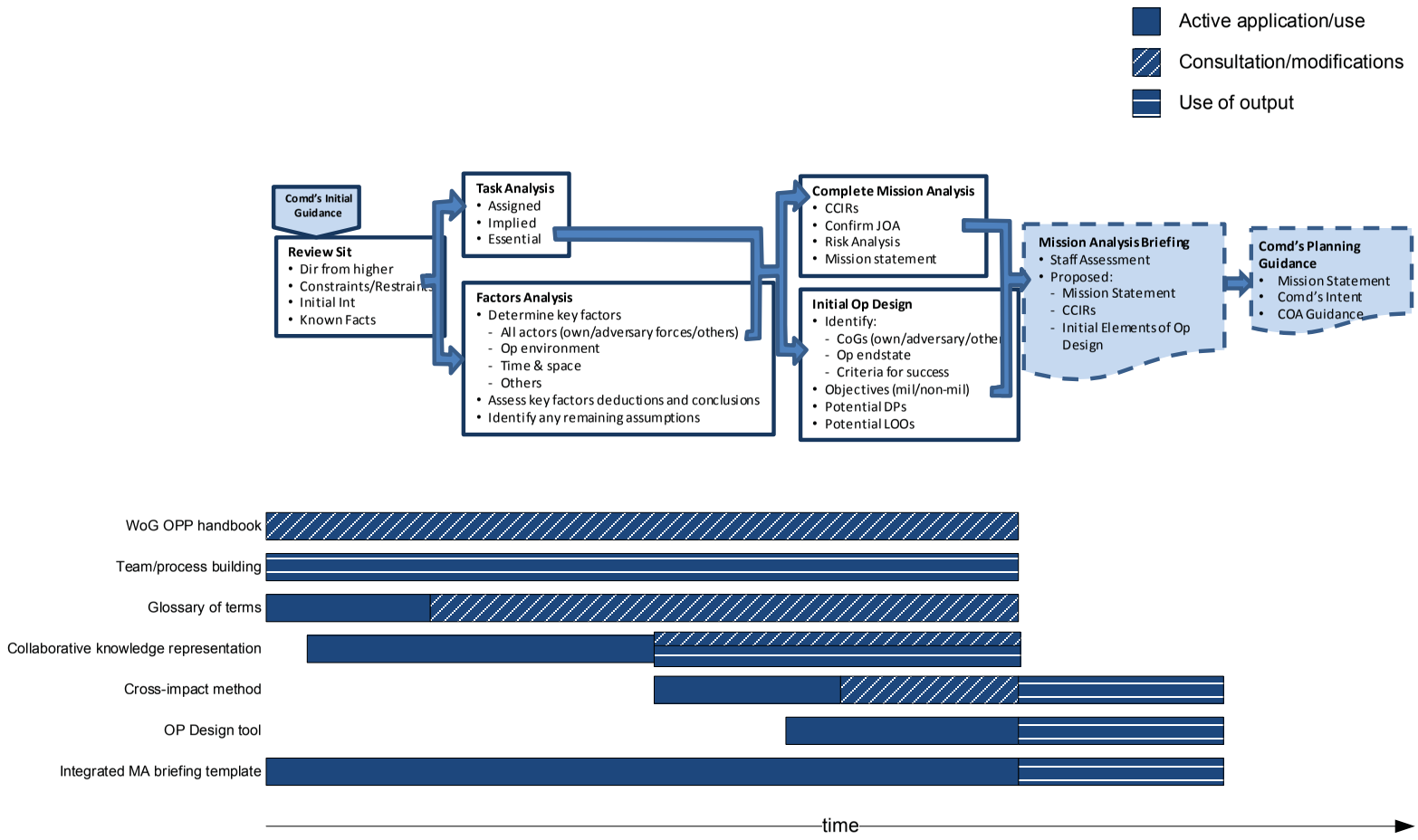

Figure 6: Suggested use of the 12om methodology components during the orientation phase of the OPP.

3 Conclusion

Hrychuk and Gizewski (2010) describe the Comprehensive Approach as seeing "diplomatic, defence, development and commercial resources, aligned with those of numerous other agencies, coordinated through an integrated campaign plan and applied in areas of operations as needed" (p. 2-1). According to Hrychuck and Gizawski, this approach is based on four basic tenants:

- Proactive engagement between actors;
- Shared understanding;
- Outcome-based thinking (i.e., in relation to a desired-end state); and
- Collaborative working.

The 12om methodology clearly addresses each of these four elements. The team building procedure seeks to support proactive engagement between actors, the WoG OPP handbook and interactive common glossary seek to support collaborative working, the IMAGE v3 component seeks to support shared understanding, and finally the OP Design component and cross-impact method seek to support outcome-based thinking.

Schmorrow and Boiney (2013) explain that goals can conflict at times within government departments and agencies, potentially hindering the success of WoG initiatives. Different planning time horizons also contribute to this problem. They add that "A common planning process or tool, which could be used by various government departments and agencies, as well as NGOs, would help" (p. 10-3). Schmorrow and Boiney (2013) also mention several R&D priorities to help succeed in the implementation of a comprehensive approach, including the following areas that were well covered by the 12om project:

- Methods to collect, integrate and visualize socio-cultural information necessary for supporting a comprehensive approach;
- Multi-agency modeling, simulation, and experimentation to develop a comprehensive approach operational concept;
- Tools, methods and techniques to support force synchronization; and
- Tools for forecasting first- to third-order effects to support intelligence, course of action (COA) development, and decision making.

Taking an empirical approach (LOEs and SME workshops with data collection) was a valuable way to inform the development of the 12om process and tools and to ensure that the solutions were indeed effective in supporting the interagency planning process. One reason for this is that best practices for an effective comprehensive approach are still unclear. In light of this, Smith, Pavlovic, Eustace, Fortier, Boiney, Vogelaar, Lawrence, Shockey, McAuliffe and Roy (2013) highlight the importance of empirical work using data collected from human-in-the-loop experiments to identify such best practices. One possible criticism of the present work is that it relied strongly on subjective ratings from SMEs.

While this information is of great value, subjective judgments can be prone to biases. Future work would indeed benefit from placing a greater effort on collecting objective process and outcome measures.

3.1 Limitations and Mitigation

Despite the extensive work that was performed in the development of the 12om methodology, there are some known limitations that should be made aware of. This section lists the main identified limitations of the 12om methodology and provides potential mitigating interventions when possible.

The first main limitation concerns a subset of the components which are very specific to the OPP. This is the case for the WoG OPP handbook, the integrated mission analysis briefing template, and the Op Design tool (although the latter is slightly less specific to OPP, it remains strongly tied to military mission planning). This, of course, is only a limitation if one wishes to apply the 12om methodology in other contexts. However, there are several advantages to being specific, such as specialisation. The main mitigation intervention for this is to provide generic components as well within the 12om toolbox (which is already the case) so that the planning teams still have tools to choose from when outside the context of OPP. Another potential mitigating intervention would be to develop more generic versions of these components.

The second limitation is the time and effort required for applying the 12om methodology. Although the methodology is intended to be modular, any component integrated within the planning process represents (or is at least perceived as) an overhead in comparison to what is already usually done. Several mitigating measures could however be done to overcome this limitation. Training of the 12om methodology could be integrated to the CF Officer curriculum and would be consequently become the "usual". Moreover, as previously discussed, the development of a more efficient training could reduce both time for training and using the components in operational contexts. Finally, also as discussed before, the integration of a 12om facilitator within a planning team could also help in reducing the time and effort required for employing the methodology.

3.2 Next Steps

Future work could be centered on the mitigating interventions mentioned above: (a) develop more generic components, (b) develop a more efficient training process, and (c) develop and integrate a new facilitator role.

3.2.1 Generic Components

Although the context used for demonstration, development and validation purposes was the OPP, the 12om project seeks to develop a methodology (i.e., process and tools) to improve the understanding of a complex situation by a multidisciplinary, government-wide team. It is not intended specifically only for the OPP. From that perspective, some of the components may be too specific to the context of OPP and may consequently benefit from a decrease in terms of specificity. For instance, the OPP handbook could be reviewed as a

"best-practice in planning handbook". The same logic could apply to the briefing template as well. It might also be worth investigating the terms employed in the Op Design tool to see how they could be "translated" into more civilian terms such as the ones used in results-based management, for instance.

3.2.2 Develop More Efficient Training

Training time and effort was a major concern for the participants at the workshops and experimentation (see LOE#2 results). Although some of the components are relatively simple and intuitive, other components may require long training time and effort, especially in order to use the more complex features. This is the case, for instance, of the IMAGE v3 component for which the basic individual knowledge representation features were deemed relatively easy to use but for which the graph querying feature necessitated more training.

We propose that a "small scale" serious game would be an optimal way for team members to practice the methodology within a short time frame, and to get a sense of the significant potential of the 12om methodology components and their synergies. A serious game helps to gain experience without any negative impact on reality. It enables the trainee to carry out actions with the actual 12om components, without fear and risks he could not carry out in reality, because their analysis would be too slow, too fast, too expensive, too complex or too dangerous (Reuters et al., 2009). Moreover, the serious gaming approach gives the trainee a coherent training example throughout the whole 12om process.

Serious game technology is an effective means to meet a wide variety of training requirements and is particularly well suited to developing the cognitive skills necessary to turn a team of experts into an expert team (Roman & Brown, 2008). The learning process is composed of four main steps:

1. Concrete experience;
2. Observation of and reflection on that experience;
3. Formation of abstract concepts based upon the reflection;
4. Testing the new concepts.

Based on this model, serious games can be designed to facilitate iteratively proceeding all of these 4 steps (Tremori, Baisini, Enkvist, Bruzzone, & Nyce, 2012). Indeed, serious games can be very powerful tools for developing skills and analytical abilities for decision-making, for developing knowledge and also to change individual and personal attitudes.

Serious games provide the opportunity for immersive practice so trainees can develop the skills necessary for dealing effectively and efficiently with whole-task decision-making, whereas experiencing the overload and anxiety associated with real-life crises (Sniezek et al., 2002). Such a virtual experience avoids the risk of costly error inherent in trial and error learning, while providing some of the benefits of actual experience, such as facing

psychological pressure, engaging in sensemaking, and recognizing when constraints such as rules are helpful or not (Moynihan, 2009).

3.2.3 Develop and Integrate a New Facilitator Role

The inclusion of an interagency planning specialist/facilitator (with modeling expertise) in a WoG team could go a long way for reducing the training burden on the rest of the team. The version 1.0 of the 12om process does include a facilitator, but the tasks and the precise goals associated with this role are yet to be defined. Task analysis methods focusing on the 12om methodology could help in defining the exact role carried out by the facilitator. In particular, while the core features of the IMAGE v3 tool were regarded as valuable for most users, the more complex, using the specialized features would require a particularly well-designed training package or be supported by a specialized facilitator. One additional potential advantage of having an interagency planning specialist within the team could be to ensure that one team member is not associated to a specific line of operation. Having such a team member with no a priori agenda could also help ensure a balanced consideration of factors. Finally, since the key element to improve in the 12om methodology is Common Understanding, one of the key roles of the specialist/facilitator could be to actively gage and support this particular element – particularly using communication reflection techniques such as mirroring and paraphrasing.

3.3 Concluding Remark

The 12om methodology's toolbox approach emphasizes flexibility and provides a coherent framework for complex problem solving. While some components are very intuitive and can be learned without any major effort, it seems somewhat inevitable that using other components will require significant mental effort to succeed in understanding complex situations. Nonetheless, the 12om methodology is believed to succeed in facilitating this difficult process. Fritz-Millett (2013) states that practical tools and metrics are required to optimise the implementation of a comprehensive approach. For instance, based on results from the Canadian Army Experiment 10, he notes that various diagramming, modelling and discourse capture toolsets need to be incorporated into the WoG approach to complex problem solving and that such toolsets would need to be capable of adaptation to diverse group needs. The 12om methodology provides just that, and will hopefully be exploited by Canada and its partners to positively impact future comprehensive approach initiatives.

References

Armenis, D. (2007). Dealing with Battlefield Complexity: A Decision Maker's Perspective. *Proceedings of the 8th Asia-Pacific Complex Systems Conference*.

Banach, S. J. (2009). Educating by Design: Preparing Leaders for a Complex World. *Military Review*, *(March-April),* 95-104.

Banach, S., & Ryan, A. (2009). The Art of Design, A design Methodology. *Military Review*, *(March-April),* 105-115.

Dieckmann, A., & Rieskamp, J. (2007). The Influence of Information Redundancy on Probabilistic Inferences. *Memory and Cognition, 35,* 1801–1813.

Dörner, D. (1996). *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations.* Reading, MA: Addison-Wesley.

Endsley, M. R. (1988). Situation Awareness Global Assessment Technique (SAGAT). In *Proceedings of the National Aerospace and Electronics Conference* (pp. 789–795). New York, NY: IEEE.

Endsley, M. R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors, 37*, 32–64.

Essens, P., Febbraro, A.R., Thompson, M.M., and Baranski, J.V. (2013). Collaboration in a Comprehensice Approach to Operations: Introduction. Paper presented at the NATO STO-MP-HFM-204 AC/323(HFM-204)TP/524 Meeting: *Collaboration in a Comprehensive Approach to Operations: Effective Collaboration in Joint, Multinational, Multiagency Teams and Staffs.* Toronto, Canada, 04-06 October, 2010. Available at: http://ftp.rta.nato.int/public//PubFullText/RTO/MP/STO-MP-HFM-204///MP-HFM-204-01.pdf

Fritz-Millett, S. (2013). A Trainer's Perspective on Research & Development in Support of the Comprehensive Approach. Paper presented at the NATO STO-MP-HFM-204 AC/323(HFM-204)TP/524 Meeting: *Collaboration in a Comprehensive Approach to Operations: Effective Collaboration in Joint, Multinational, Multiagency Teams and Staffs.* Toronto, Canada, 04-06 October, 2010. Available at: http://ftp.rta.nato.int/public//PubFullText/RTO/MP/STO-MP-HFM-204///MP-HFM-204-11.pdf

Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic Decision Making. *Annual Review of Psychology*, *62*, 451–82. doi:10.1146/annurev-psych-120709-145346

Gigerenzer, G., & Selten, R. (Eds.). (2001). *Bounded Rationality: The Adaptive Toolbox.* Cambridge, MA: MIT Press.

Gigerenzer, G., Todd, P. M., & The ABC Research Group (1999). *Simple Heuristics That Make Us Smart*. New York, NY: Oxford University Press.

Gordon, T. J. (1994). *Cross Impact Method.* United Nation University Millennium Project, Futures Research Methodology.

Grisogono A. M., & Ryan, A. J. (2007). Operationalising Adaptive Campaigning. *In Proceedings of International Conference of the System Dynamics Society*, June 19-21, Newport, RI. 2007.

Heuer, R. J. Jr., & Pherson, R. H. (2011). Structured Analytic Techniques for Intelligence Analysis. CQ Press.

Hrychuk, H., & Gizewski, P. (2013). Developing the Comprehensive Approach: Exploring the Lessons of History. Paper presented at the NATO STO-MP-HFM-204 AC/323(HFM-204)TP/524 Meeting: *Collaboration in a Comprehensive Approach to Operations: Effective Collaboration in Joint, Multinational, Multiagency Teams and Staffs.* Toronto, Canada, 04-06 October, 2010. Available at: http://ftp.rta.nato.int/public//PubFullText/RTO/MP/STO-MP-HFM-204///MP-HFM-204-02.pdf

Karelaia, N., & Hogarth, R. M. (2008). Determinants of Linear Judgment: A Meta-Analysis of Lens Model Studies. *Psychological Bulletin*, *134*(3), 404–26. doi:10.1037/0033-2909.134.3.404

Lafond, D., Beattie, A., DuCharme, M.B., Tremblay, S. (2012). Collaborative Decision Making in a Simulated Stability Operations Exercise: A Prototype Decision Support Tool. *Proceedings of the 30th International Conference of the System Dynamics Society*. St. Gallen, Switzerland, July 22 – July 26.

Lafond, D., DuCharme, M.B., Gagnon, J.-F., & Tremblay, S. (2012). Support Requirements for Cognitive Readiness in Complex Operations. *Journal of Cognitive Engineering and Decision Making. Special Issue "Exploring Cognitive Readiness in Complex Operational Environments: Advances in Theory and Practice, 6,* 393-426.

Lauder, M. (2009). Systemic Operational Design: Freeing Operational Planning from the Shackles of Linearity. *Canadian Military Journal*, *9*(4), 41- 49.

Leslie, A., Gizewski, P., & Rostek, M. (2008). Developing a Comprehensive Approach to Canadian Forces Operations. *Canadian Military Journal, 9,* 11-20.

Ludy, P. J. (2000). *Profit Building: Cutting Costs Without Cutting People*. San Francisco: Berret-Koehler.

Marewski, J. N., & Schooler, L. J. (2011). Cognitive Niches: An Ecological Model of Strategy Selection. *Psychological Review*, *118*(3), 393–437. doi:10.1037/a0024143

Miller, A. (1982). Tunnel Vision in Environmental Management. *The Environmentalist, 2,* 223-231.

Moynihan, D. P. (2009). From Intercrisis to Intracrisis Learning. *Journal of Contingencies and Crisis Management, 17*(3), 189-198.

Osborn, A.F. (1963). *Applied Imagination: Principles and Procedures of Creative Problem Solving* (Third Revised Edition). New York, NY: Charles Scribner's Sons.

Patrick, S., & Brown, K. (2007). Greater Than the Sum of Its Parts? Assessing 'Whole of Government' Approaches to Fragile States. New York, NY: International Peace Academy.

Putz-Osterloh, W. (1993). Strategies for Knowledge Acquisition and Transfer of Knowledge in Dynamic Tasks. In G. Strube, & K. F. Wender (Eds.), *The Cognitive Psychology of Knowledge* (pp. 331-350). Amsterdam: Elsevier.

Reuter, C., Pipek, V., & Mueller, C. (2009). Computer Supported Collaborative Training in Crisis Communication Management. *Proceedings of the 6th International ISCRAM Conference*. Gothenburg, Sweden.

Rieskamp, J., & Otto, P. E. (2006). SSL: A Theory of How People Learn to Select Strategies. *Journal of Experimental Psychology: General, 135,* 207–236.

Roman, P. A., & Brown, D. (2008). Games – Just How Serious Are They? *Interservice/Industry Training, Simulation, and Education Conference* (pp. 1-11). Orange County.

Rousseau, C. (2003). Complexity and the Limits of Modern Battlespace Visualization. *Canadian Military Journal, Summer,* 35-44.

Schoppek, W. (2002). Examples, Rules, and Strategies in the Control of Dynamic Systems. *Cognitive Science Quarterly, 2,* 63-92.

Smith, D., Pavlovic, N., Eustace, D., Fortier, A., Boiney, J. A., Vogelaar, A., Lawrence, K., Shockey, K., McAuliffe, C., & Roy, R. (2013). Report Working Group 1 Capability Gaps, Knowledge Gaps, and Data Gaps in the Collaboration in Comprehensive Approaches to Operations." Paper presented at the NATO STO-MP-HFM-204 AC/323(HFM-204)TP/524 Meeting: *Collaboration in a Comprehensive Approach to Operations: Effective Collaboration in Joint, Multinational, Multiagency Teams and Staffs.* Toronto, Canada, 04-06 October, 2010. Available at: http://ftp.rta.nato.int/public//PubFullText/RTO/MP/STO-MP-HFM-204///MP-HFM-204-14.pdf

Schmorrow, D., & Boiney, J. A. (2013). How Human Social Culture Behavior Modeling Can Support a Comprehensive Approach to Operations. Paper presented at the NATO STO-MP-HFM-204 AC/323(HFM-204)TP/524 Meeting: *Collaboration in a Comprehensive Approach to Operations: Effective Collaboration in Joint, Multinational, Multiagency Teams and Staffs.* Toronto, Canada, 04-06 October, 2010. Available at: http://ftp.rta.nato.int/public//PubFullText/RTO/MP/STO-MP-HFM-204///MP-HFM-204-10.pdf

Sniezek, J. A., Wilkins, D. C., Wadlington, P. L., & Baumann, M. R. (2002). Training for Crisis Decision-Making: Psychological Issues and Computer-Based Solutions. *Journal of Management Information Systems, 18*(4), 147-168.

Sterman, J. D. (2006). Learning from Evidence in a Complex World. *American Journal of Public Health, 96,* 505-514.

St-Louis, M.-H. (2009). The Strategic Advisory Team in Afghanistan – Part of the Canadian Comprehensive Approach to Stability Operations. *Canadian Military Journal, 9,* 58-67.

Turnbull, A., & Ulrich, P. (2013). Canadian Military-Civilian Relationships within Kandahar Province. Paper presented at the NATO STO-MP-HFM-204 AC/323(HFM-204)TP/524 Meeting: *Collaboration in a Comprehensive Approach to Operations: Effective Collaboration in Joint, Multinational, Multiagency Teams and Staffs.* Toronto, Canada, 04-06 October, 2010. Available at: http://ftp.rta.nato.int/public//PubFullText/RTO/MP/STO-MP-HFM-204///MP-HFM-204-05.

Tremori, A., Baisini, C., Enkvist, T., Bruzzone, A. G., & Nyce, J. M. (2012). Intelligent Agents and Serious Games for the Development of Contextual Sensitivity. In V. G. Duffy (Ed.), *Advances in Applied Human Modeling and Simulation* (pp. 123–133). CRC Press.

Warner, N., Letsky, M., & Cowen, M. (2005). Cognitive Model of Team Collaboration: Macro-Cognitive Focus. *In Proceedings of the 49th Human Factors and Ergonomics Society Annual Meeting,* Orlando, FL.

Appendix A – Key Findings from LOE #2

Using the MYRIAD multi-criteria analysis tool, a preference model that combines different key results into a coherent assessment of the overall 12om methodology and its components was designed. Furthermore, MYRIAD allowed performing a sensitivity analysis that derives the most promising areas for improvement.

General Findings

Overall, the 12om methodology was rated very favourably, and no components were identified as missing or as superfluous. All components were rated relatively favourably in terms of the compromise between support and feasibility of implementation. The main strength of the 12om methodology is in supporting the three dimensions of Collaborative Understanding (i.e., collaboration support, integration of different perspectives, common understanding) in a very balanced way. Furthermore, its support was found to cover all tasks associated with the OPP. The main challenge identified by this analysis was the overall need to address the issue of training time/effort.

Team dynamics analyses all pointed toward excellent team collaboration. Social network analysis of communications clearly showed the active leading role of the J5 (which was expected). All participants save J5 had similar sociometric status, emission degrees and reception degrees, revealing similar levels of participation during the exercise. Content analysis suggested that members of the WoG team made efforts for integrating different perspectives during the process since the development-related content (which is often left apart in "integrated" operations) was by far the most important topic at some point during the LOE #2. Finally, the transactive memory system measurement instrument showed that the members of the WoG team perceived the other team members as being credible and found that coordination within the team was good.

Accordingly, no major changes are warranted in this third iteration of the 12om process development. Nonetheless, analyses revealed that future work on the 12om methodology should prioritize changes that would improve common understanding. Note that this is not because common understanding was poorly supported but rather because the sensitivity analysis showed that further supporting this dimension in particular would have the most impact overall.

Component-Specific Findings

Individual component assessments varied between 63% and 82% showing that there is still room for improvement, and giving a magnitude of priority in terms of what components need the most improvement. Results for the eight main components and four IMAGE v3 subcomponents are summarized in Table A1.

Table A1. MYRIAD output for the 12om methodology components analysis

Component	Score
OP Design Tool	82%
Conceptual Diagrams (Collaborative)	76%
Team Building and Handover Procedure	76%
Common Glossary	76%
OPP Handbook	71%
WoG MA Brief Template	70%
Conceptual Diagrams (Individual)	68%
CIM	63%
Sub-component	**Score**
Creating a Common Vocabulary	81%
Sharing Conceptual Diagrams	69%
Creating Views Using Filters	68%
Querying Using Filters	68%

Note that prior to LOE #2 some component names have been revised and some components split in two. OP Design was divided into *OP Design Tool* and *OP Design Process (and since the latter is part of military doctrine it was not considered during the 12om MYRIAD assessment).* IMAGE v3 has been divided into Conceptual Diagrams (Individual) and Conceptual Diagrams (Collaborative).

Only a few sub-components were rated as being characterized by lower or equivalent usability than similar tools in this context: i.e., sharing conceptual diagrams, querying conceptual diagrams using filters, and creating views using filters. Similarly, in terms of cost-benefit ratings, the lowest ratings were associated with the IMAGE v3 tool sub-components: sharing conceptual diagrams and querying conceptual diagrams using filters. Taken together, the above results suggest that the core features of the IMAGE v3 tool are valuable for most users, but that the more complex, specialized features should be trained further or supported by a specialized facilitator. The *creation of a common vocabulary* sub-component of IMAGE v3, however, proved to be a particularly valued sub-component of IMAGE v3.

A short summary of the multicriteria assessment results is shown below:

WoG OPP handbook

The main weakness of this component is its relatively low impact on taskwork, since it is mainly categorised as reference material. Results in terms of feasibility are relatively good. According to the sensitivity analysis, improving any of the four dimensions of support is deemed equally beneficial.

Team building and handover procedure

The main weakness of this component is its relatively low impact on taskwork, since it is mainly categorised as reference material. Otherwise, with the exception of a moderately

demanding use time/effort, results are extremely favorable. According to the sensitivity analysis, the priority areas for improvement are OPP support, Integration of perspectives, Common understanding, and Impact on taskwork.

Common glossary

The sole weakness of this component is its relatively low impact on taskwork, since it is mainly categorised as reference material. According to the sensitivity analysis, the most valuable areas for improvement are Impact on taskwork, OPP support, Common understanding, and Collaboration support.

Conceptual diagrams (individual)

The main weakness of this component is related to feasibility in terms of time and effort required for training and use. However, despite these difficulties, this component is deemed highly valuable especially because of its important impact on the taskwork to perform. According to the sensitivity analysis, the key areas for improvement are 1) Any one of dimension of support (other than impact on taskwork which cannot be further improved); 2) Reduce use time/effort (e.g., place a time limit on list of concepts/relations); and 3) Reduce training time/effort.

Conceptual diagrams (collaborative)

The main weakness of this component relates to feasibility, specifically its demanding use time/effort. Nonetheless, this component is deemed highly valuable because of its high positive impact on the taskwork, and is the component with the highest (94%) satisfaction in terms of overall support provided. According to the sensitivity analysis, the key areas for improvement are: 1) Reduce use time/effort; and 2) Reduce training time/effort.

Cross-impact method

The main weakness of this component is feasibility, specifically in terms of its use time/effort. Nonetheless, this component is deemed highly valuable in terms of its impact on the taskwork and received quite high usability ratings when considering the nature of the analytical method. According to the sensitivity analysis several possible areas for improving the cross-impact method are equally viable: 1) Reduce use time/effort; 2) Increase OPP Support; 3) Improve Integration of Perspectives; 4) Increase support to Development of Common Understanding; 5) Improve support to Collaboration; and 6) Reduce training time/effort.

OP design tool (DP analysis)

With an 82% satisfaction based on the multicriteria analysis, this is the most successful component in the 12om methodology. According to the sensitivity analysis, the four main areas that would benefit the most from improvement are: 1) Impact on taskwork (which was already relatively high); 2) Integration of Perspectives; 3) Common Understanding; and 4) Collaboration Support.

WoG MA brief template

Its sole weakness is its relatively low impact on taskwork, since it is mainly categorised as reference material. This component *has the greatest feasibility* (85%) amongst the different components considered here. According to the sensitivity analysis four equally good areas

for improvement are: 1) Impact on taskwork; 2) OPP support; 3) Integration of perspectives; 4) Common understanding; and 5) Collaboration support.

Flexibility and Impact of the 12om Components

A functional gap analysis provided useful information on the flexibility and impact on taskwork of the 12om methodology components. Table A2 shows where the main 12om components provide support and what is the relative impact on taskwork it provides. Each line represents a component, which is plotted against CFOPP sub-tasks and 12om objective. A "1" was entered whenever the analysis revealed that a component was supporting a sub-task or an objective. Between parentheses, the number indicates the relative impact of that component.

Table A2. Summary of support to OPP and 12om objectives by methodology component

	Initiation			Orientation						COA development					Objectives				
	Comd's/ROC initial assessment	Activate planning staff	Comd's initial guidance	Review siuation	Task analysis	Factors analysis	Complete mission analysis	Initial OP Design	MA Brief	Initial COA development	Info briefing	COA analysis	Decision briefing	CONOPS	Integration of perspectives	Shared understanding	Collaboration	Sum	Weighed sum
WoG OPP handbook	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	17	17
WoG MA brief template							1(1)		1(1)									2	2
OP Design tool					1(3)			1(3)	1(3)	1(3)	1(3)	1(3)		1(3)				7	21
Cross-impact method				1(4)	1(4)	1(4)			1(4)									4	16
Conceptual diagrams				1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	1(4)	14	56
Common glossary	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	1(1)	17	17
Team building and handover		1(1)													1(1)	1(1)	1(1)	4	4
Sum	2	3	2	4	5	4	4	4	6	4	4	4	3	4	4	4	4	65	
Weighed sum	2	3	2	10	13	10	6	7	14	9	9	9	6	9	7	7	7		133

The analysis shows that all components do not provide support throughout the whole CFOPP. Some components, such as the WoG OPP handbook and Common glossary, are very flexible as they provide support to most if not all sub-tasks of the CFOPP. However, on the other hand, they have relatively low impact on taskwork because they are not used directly to generate a product. Moreover, it highlights the differential impact of the components on taskwork to perform. For instance, it shows that although OP Design tool is not very flexible, it has a strong impact on task work.

Table A2 is intended to provide information for the selection of the appropriate components to use in a given situation. It may help deciding on the exact toolset that a commander and interagency planning team members may want to have while carrying our mission.